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(54) **Pedestrian impact sensor system**

(57) A pedestrian impact sensor system for a motor vehicle comprises sensing means (4) for measuring the loads acting simultaneously on different regions across the front of the vehicle to produce a pressure pattern

(12). The system includes means (14, 17) for monitoring changes in measured pressure patterns over time, and for comparing these changes with data characteristic of pedestrian collisions. If a correspondence is identified, a signal is sent to activate a cushioning device (16).

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## Description

[0001] The present invention relates to an impact sensor system for use in triggering operation of a deployable device for protecting a pedestrian hit by the front of a vehicle. The invention also relates to an impact sensing method and to a pedestrian protection system which employs the impact sensor system.

[0002] When a pedestrian is hit by a motor vehicle, for example a car, the worst injuries tend to be caused by subsequent collision between the pedestrian's head and the bonnet of the vehicle. Many impact protection systems have been devised to reduce the effects of such collisions, for example bonnet-mounted airbags or energy-absorbing bonnet panels. See for example British Patent Application 2 316 371. Such deployable systems will be referred to as cushioning devices.

[0003] Cushioning devices require a sensor to be used to detect pedestrian impacts, and it is highly desirable for that sensor to discriminate between impact with a pedestrian and other types of impact. The decision of whether to deploy or not to deploy must be made in a very short space of time after detecting an initial impact at the front of the vehicle.

[0004] One pedestrian impact sensor system which has been proposed is described in International Patent Application No. WO 97/18108. This system uses a first sensor on the front bumper (fender) and a second sensor on the front edge of the bonnet (hood) of the vehicle. By measuring the time difference between triggering of the first sensor and triggering of the second sensor, and the magnitudes of the signals from those sensors, the system can distinguish between impacts with pedestrians and other sorts of impact.

[0005] It is necessary for there to be an impact between the pedestrian and the vehicle bonnet before any deployment of a safety device can be triggered.

[0006] According to an aspect of the present invention there is provided a pedestrian impact sensing system for a motor vehicle as specified in claim 1.

[0007] By measuring a changing pressure pattern across the front of the vehicle, it is not necessary to detect collision with the bonnet of the vehicle.

[0008] Moreover, the system can discriminate between a pedestrian collision and collision with an object such as a bollard, so that deployment of the cushioning device happens only in the event of a pedestrian collision.

[0009] Preferably the sensing means are located in the front bumper of the vehicle. This permits the use of a single pressure sensitive matrix associated with the bumper. For convenience hereinafter the invention will be described with reference to a pressure sensitive matrix in a front bumper. However, it is to be understood that the invention is not limited to this embodiment.

[0010] The pressure pattern, rather than the magnitude of loading of individual matrix cells, principally characterises a pedestrian impact, while the change of pres-

sure pattern with time provides discrimination data relating to magnitude. An advantage of this system is that variation in material properties of the bumper system, for example due to environmental effects or manufacturing variation, may affect the magnitude of load measured by individual cells, but will not significantly affect the pressure pattern.

[0011] The comparison means preferably comprises a neural network, which is particularly able to be adaptable to complex cases. However, a conventional algorithm could also be used.

[0012] Suitable known matrix technologies may be used for the pressure sensitive matrix, for example force-sensitive resistors, capacitive arrays, strain gauges and piezoresistive or capacitive load cells.

[0013] The pressure sensitive matrix may be sandwiched between a rigid bumper beam and the bumper cover or trim panel. An energy absorbing module, for example a foam module, is preferably held under compression against the matrix. The matrix may be sandwiched between the foam module and the bumper beam, between the foam module and the bumper cover, or within the foam module.

[0014] In a particularly preferred embodiment, the bumper is provided with a plurality of discrete loading features, each corresponding to a region of the bumper where an element of the pressure pattern is to be measured. Each loading feature may comprise a projection in the bumper cover, in the foam module, or in the pressure sensitive matrix. The loading features improve load transmission to the sensor elements of the matrix.

[0015] Any vehicle systems that use a radiated field (for example radar, infrared, ultrasound, or microwave) to establish conditions outside the vehicle exterior could be used as a low-level trigger to activate a high processing rate in the impact sensor system. For example, if an automatic cruise control system sensed relative movement between the vehicle and an external object, the pedestrian impact sensor could commit system resources to discriminating an impact, given the higher level of event confidence gained. This information could also be used in the deployment decision-making process, similar to an interior airbag controller's "safing" sensor.

[0016] A further aspect of the present invention provides a method for detecting pedestrian impact with a motor vehicle, as specified in claim 10.

[0017] According to another aspect of the present invention there is provided a pedestrian protection system for a motor vehicle, as specified in claim 11.

[0018] The invention will now be further described, by way of example, with reference to the following drawing in which:

Figure 1 is an exploded view of a vehicle bumper for use in a pedestrian impact sensor system in accordance with one aspect of the present invention; Figure 2 is a view from the rear of a portion of the foam module of Figure 1;

Figure 3 is a sectional view along the line A-A of Figure 2;

Figure 4 shows graphically an example of information presented by sensing means to a signal processor in a pedestrian impact sensor system in accordance with one aspect of the present invention; and

Figure 5 shows schematic views of pedestrian protection systems in accordance with another aspect of the present invention.

[0019] The vehicle bumper shown in Figure 1 comprises a rigid beam 2 and a cover 8. Sandwiched between the beam 2 and the cover 8 are a pressure sensitive matrix 4 and a foam module 6. The foam module 6 is held in compression against the pressure sensitive matrix 4 so that the force of an impact of an object against the cover 8 is partially transmitted to the matrix 4.

[0020] To facilitate force transmission in predetermined regions of the matrix 4, the foam module 6 is provided with a plurality of vertically and horizontally spaced apart loading features 10, comprising moulded projections or nubs. Each projection corresponds to a region where a pressure reading will be taken and which will map to a picture element in a pressure pattern 12.

[0021] In the system shown in Figure 5a, the pressure sensitive matrix 4 sends pressure information for each loading feature 10 to a signal processor 14, for example a neural network. The signal processor 14 monitors changes in the pressure pattern over time and determines whether a correspondence exists between the changing pressure pattern and stored data for changing pressure patterns characteristic of pedestrian collisions. If a correspondence is identified, the signal processor sends a triggering signal to a cushioning device 16, for example a bonnet-mounted airbag, so that the cushioning device is deployed.

[0022] The pressure sensitive matrix 4 may provide a decision or data to a central airbag controller 17, which has the ability to trigger deployment of the airbag 16. The airbag controller 17 may include the processing capability of the signal processor 14. These options are shown in Figures 5b and 5c.

[0023] Examples of the type of pressure patterns 12 transmitted from the pressure sensitive matrix 4 to the signal processor 14 are shown in Figure 4. Picture elements from left to right as viewed correspond to sensing regions across the bumper, and picture elements from top to bottom as viewed correspond to sensing regions up and down the bumper. The left hand pattern is measured at 5 ms after an impact, and the right hand pattern is measured at 15 ms. In this illustration, each picture element can have only three states, namely high, medium, and low, it would of course be possible to make the system more discriminating by measuring finer differences in pressure, or by providing a greater density of sensing regions. This increased discrimination would be

at the cost of increasing the necessary processing resources to analyse the greater amount of data in the changing pressure patterns. The allocation of higher processing resources to the pedestrian impact system could be increased in response to a signal from a vehicle system which detects relative movement between the vehicle and an external object.

[0024] The invention therefore provides pedestrian sensing and cushioning systems which do not require sensing of bonnet collision and which are tolerant of manufacturing and environmental variations.

## Claims

1. A pedestrian impact sensing system for a motor vehicle, the system comprising sensing means (4) for measuring the loads acting simultaneously on different regions across the front of the vehicle to produce a pressure pattern (12), means (14, 17) for monitoring changes in measured pressure patterns over time, means (14, 17) for comparing the changing pressure patterns (12) with stored data for changing pressure patterns characteristic of pedestrian collisions, and means (14, 17) for sending a triggering signal for activating a cushioning device (16) when a correspondence is identified between a measured changing pressure pattern and stored data.
2. A pedestrian impact sensing system as claimed in claim 1, wherein the sensing means (4) is housed in the front bumper (2, 8) of the vehicle.
3. A pedestrian impact sensing system as claimed in claim 1 or claim 2, wherein the sensing means comprises a pressure sensitive matrix (4).
4. A pedestrian impact sensing system as claimed in any one of the preceding claims, wherein the correspondence identifying means comprises a neural network (14).
5. A pedestrian impact sensing system as claimed in claim 2, wherein the sensing means (4) is sandwiched between a rigid bumper beam (2) and a bumper cover (8).
6. A pedestrian impact sensing system as claimed in claim 5, wherein an energy absorbing module (6) is held in compression between the bumper cover (8) and the sensing means (4).
7. A pedestrian impact sensing system as claimed in claim 6, wherein the bumper is provided with a plurality of discrete loading features (10), each corresponding to a region of the bumper where an element of the pressure pattern (12) is to be measured.

8. A pedestrian impact sensing system as claimed in claim 7, wherein the loading features comprise nubs or projections (10) on the energy absorbing module (6).

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9. A pedestrian impact sensing system as claimed in any one of the preceding claims, further including means for detecting relative movement between the vehicle and an external object, means for producing a signal in response to detection of this movement, and means for increasing system resources available to the comparison means (14, 17) in response to the signal.

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10. A method for detecting pedestrian impact with a motor vehicle, comprising:

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measuring loads acting simultaneously across the front of the vehicle to produce a pressure pattern (12);  
 monitoring changes in measured pressure patterns over time;  
 comparing the changing pressure patterns with stored data for changing pressure patterns characteristic of pedestrian collisions to determine if there is a correspondence;  
 sending a triggering signal to activate a cushioning device (16) if a correspondence is identified.

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11. A pedestrian protection system for a motor vehicle, comprising:

a cushioning device (16) for cushioning an impact with a pedestrian, being actuatable by a triggering signal;  
 sensing means (4) for measuring the loads acting simultaneously on different regions across the front of the vehicle to produce a pressure pattern (12);  
 means (14) for monitoring changes in measured pressure patterns over time;  
 means (14) for comparing the changing pressure patterns with stored data for changing pressure patterns characteristic of pedestrian collisions; and  
 means (14) for sending a triggering signal to the cushioning device (16) when a correspondence is identified between a measured changing pressure pattern and stored data.

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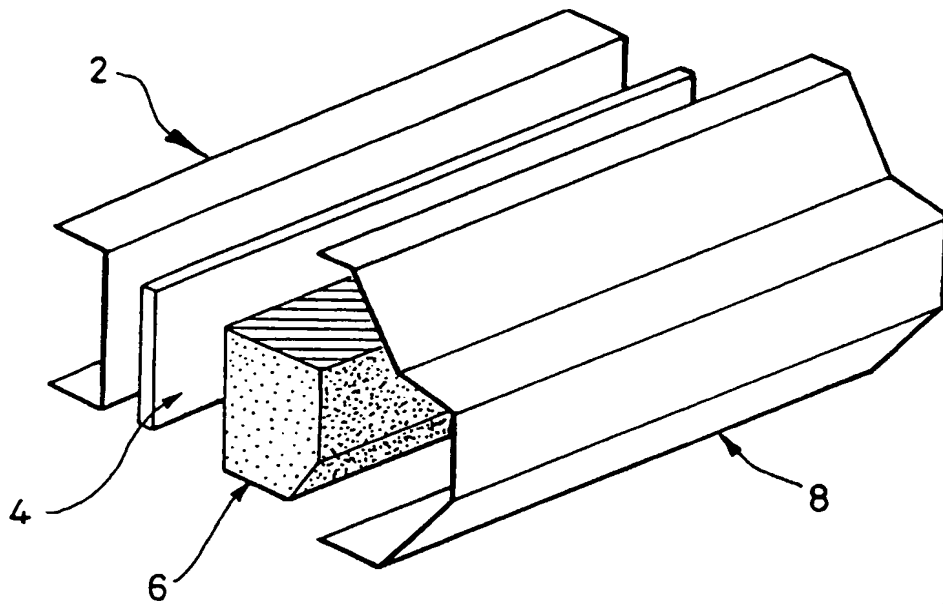


Fig. 1

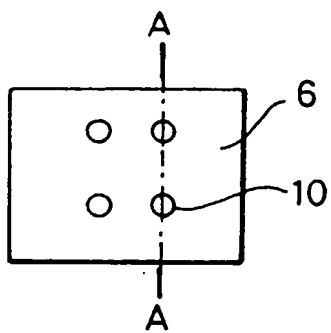


Fig. 2

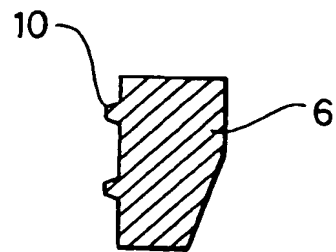


Fig. 3

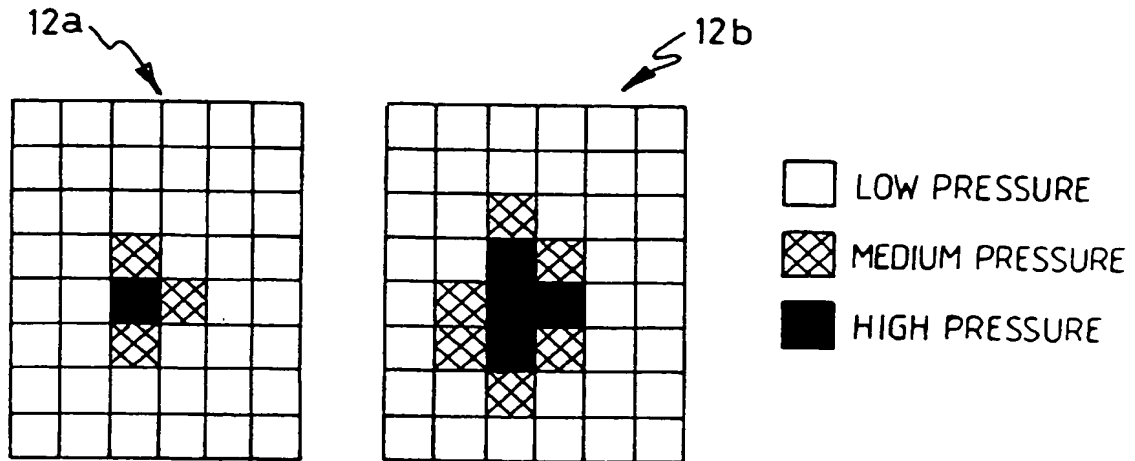
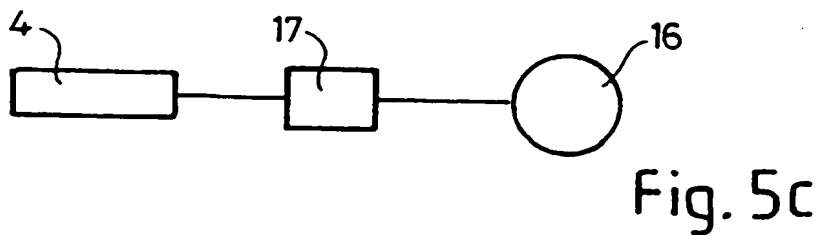
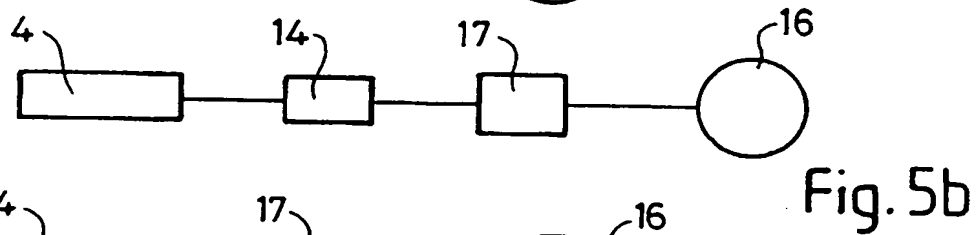
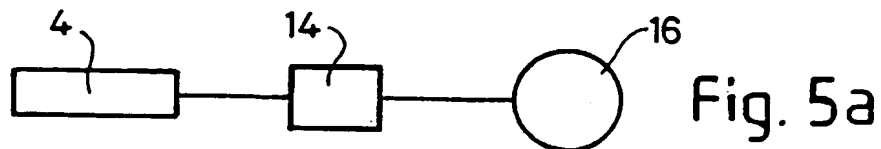


Fig. 4



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# EUROPEAN SEARCH REPORT

Application Number  
EP 99 30 3229

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
E	EP 0 937 612 A (TOYODA CHUO KENKYUSHO KK) 25 August 1999 (1999-08-25) * column 2, line 35 - line 30 * * column 11, line 54 - line 56 * * column 23, line 25 - line 31 * * column 50, line 21 - column 54, line 7 * * column 21, line 19 - column 23, line 10 * * figures 1,3B,6A,47,74, *	1,2,5,6, 10,11	B60R21/32 B60R19/48 B60R21/34
P,X	DE 197 18 803 C (FORD GLOBAL TECH INC) 22 October 1998 (1998-10-22) * column 1, line 1 - line 19 * * column 2, line 25 - line 35 * * column 2, line 43 - line 55 * * column 5, line 33 - line 63 * * figures 2,4 *	1,2,5,6, 10,11	
D,A	WO 97 18108 A (SECR DEFENCE ;GLEAVES DAVID GEORGE (GB); KAUSHAL TEJ PAUL (GB)) 22 May 1997 (1997-05-22) * page 5, line 7 - line 23 * * page 6, line 16 - line 17 * * page 7, line 10 * * figures 2-4 *	1,2,5,6	TECHNICAL FIELDS SEARCHED (Int.Cl.6)  B60R
The present search report has been drawn up for all claims			
Place of search <b>THE HAGUE</b>		Date of completion of the search <b>26 January 2000</b>	Examiner <b>Billen, K</b>
<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background C : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons &amp; : member of the same patent family, corresponding document</p>			

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ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.

EP 99 30 3229

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26-01-2000

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